CLAIMS

What is claimed is:

1. A method of improving transmit antenna weight tracking in a communication system, wherein the communication system includes a transmitter and a receiver, wherein the transmitter includes a plurality of antennae, and wherein the communication system is capable of communicating utilizing a transmit adaptive antenna weighting technique, the method comprising:
    a) determining a channel autocorrelation matrix estimate of a forward channel gain vector; and
    b) determining a transmitter antenna weight vector based on feedback from the receiver and the channel autocorrelation matrix estimate determined in the act (a).

2. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the update according to act (b) of Claim 1 comprises the following sub-acts:
    i) determining a perturbation vector autocorrelation matrix based on the channel autocorrelation matrix estimate determined in the act (a) of Claim 1;
    ii) generating a perturbation vector having an autocorrelation given by the autocorrelation matrix determined in act (i);
    iii) utilizing the perturbation vector from act (ii) in a waveform transmitted from the transmitter; and
    iv) utilizing a measurement of the waveform transmitted from the transmitter from act (iii) at the receiver to generate feedback.

3. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the communication system comprises a DS-CDMA communication system.

4. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the determining a channel autocorrelation matrix estimate act (a) further comprises normalizing the channel autocorrelation matrix estimate.

5. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the determining a channel autocorrelation matrix estimate act (a) comprises calculating an initial forward channel autocorrelation matrix estimate.

6. The method of improving transmit antenna weight tracking as defined in Claim 5, wherein the calculating the initial forward channel autocorrelation matrix estimate comprises determining the forward channel autocorrelation matrix estimate directly from a weight vector.

7. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the determining a channel autocorrelation matrix estimate act (a) comprises calculating a reverse channel autocorrelation matrix estimate.

8. The method of improving transmit antenna weight tracking as defined in Claim 2, wherein the determining a perturbation vector autocorrelation matrix act (i) comprises calculating the perturbation vector autocorrelation matrix from a forward channel autocorrelation matrix and a reverse channel autocorrelation matrix according to the following equation:

$$\mathbf{R}_v = 2\left(a_f \frac{\hat{\mathbf{R}}_f}{\left\|\hat{\mathbf{R}}_f\right\|} + a_r \frac{\hat{\mathbf{R}}_r}{\left\|\hat{\mathbf{R}}_r\right\|} + \left(1 - a_f - a_r\right)\mathbf{I} \right);$$

where a_f and a_r are algorithm parameters, wherein $0 \le a_f \le 1$, $0 \le a_r < 1$, and $0 \le (a_f + a_r) \le 1$.

9. The method of improving transmit antenna weight tracking as defined in Claim 7, wherein the calculating a reverse channel autocorrelation matrix estimate comprises the following sub-acts:

i) calculating a coherent channel vector estimate by multiplying a receiver waveform with a local version of a reverse channel pilot sequence conjugated and filtering the resultant with a filter to give the reverse channel vector estimate $\hat{\mathbf{c}}_r$;

ii) calculating an outer product $\hat{\mathbf{c}}_r \hat{\mathbf{c}}_r^H$; and

iii) filtering the outer product $\hat{\mathbf{c}}_r \hat{\mathbf{c}}_r^H$ to produce the reverse channel autocorrelation matrix estimate.

10. The method of improving transmit antenna weight tracking as defined in Claim 6, wherein the calculating a forward channel autocorrelation matrix estimate comprises the following sub-acts:

i) calculating a coherent channel vector estimate directly from a transmit weight vector to give the reverse channel vector estimate $\hat{\mathbf{c}}_f$;

ii) calculating an outer product $\hat{\mathbf{c}}_f \hat{\mathbf{c}}_f^{\ H}$; and

iii) filtering the outer product $\hat{\mathbf{c}}_f \hat{\mathbf{c}}_f^{\ H}$ to produce the forward channel autocorrelation matrix estimate.

11. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the determining a channel autocorrelation matrix estimate act (a) comprises determining a forward channel autocorrelation matrix estimate and a reverse channel autocorrelation matrix estimate according to the following equations:

$$\hat{\mathbf{R}}_f(n) = \sum_{k=0}^{\infty} h_f(k)\hat{\mathbf{c}}_f(n-k)\hat{\mathbf{c}}_f^{\ H}(n-k); \text{ and}$$

$$\hat{\mathbf{R}}_r(n) = \sum_{k=0}^{\infty} h_r(k)\hat{\mathbf{c}}_r(n-k)\hat{\mathbf{c}}_r^{\ H}(n-k).$$

12. The method of improving transmit antenna weight tracking as defined in Claim 11, wherein $h_r()$ and $h_f()$ are causal estimation filters with unit DC gain according to the following equation:

$$\sum_{k=0}^{\infty} h_r(k) = \sum_{k=0}^{\infty} h_f(k) = 1.$$

13. The method of improving transmit antenna weight tracking as defined in Claim 12, wherein the causal estimation filters are exponential filters that can be represented by the following equation:

$$h(k) = \begin{cases} 0 & k < 0 \\ (1-\lambda)\lambda^k & k \geq 0 \end{cases}.$$

14. The method of improving transmit antenna weight tracking as defined in Claim 2, wherein the determining a perturbation vector autocorrelation matrix sub-act (i) of Claim 2 comprises the following sub-acts:

    (1) calculating a forward channel autocorrelation matrix estimate;

    (2) calculating a reverse channel autocorrelation matrix estimate; and

    (3) generating the perturbation vector autocorrelation matrix from the estimates calculated in sub-acts (1) and (2).

15. The method of improving transmit antenna weight tracking as defined in Claim 14, wherein exponentiations of autocorrelation matrices are adjusted to expand or compress a tracking rate.

16. The method of improving transmit antenna weight tracking as defined in Claim 14, wherein the generating the perturbation vector autocorrelation matrix sub-act (3) generates the perturbation vector autocorrelation matrix by the following equation:

$$\mathbf{R}_v = 2\left(a_f \frac{\hat{\mathbf{R}}_f{}^p}{\left\| \hat{\mathbf{R}}_f{}^p \right\|} + a_r \frac{\hat{\mathbf{R}}_r{}^p}{\left\| \hat{\mathbf{R}}_r{}^p \right\|} + (1 - a_f - a_r)\mathbf{I} \right);$$

where a_f and a_r are algorithm parameters, wherein $0 \le a_f \le 1$, $0 \le a_r \le 1$ and $0 \le (a_f + a_r) \le 1$.

17. The method of improving transmit antenna weight tracking as defined in Claim 16, wherein the method utilizes eigendecompositions to generate the perturbation vector autocorrelation matrix.

18. The method of improving transmit antenna weight tracking as defined in Claim 17, wherein the forward channel autocorrelation matrix estimate and the reverse channel autocorrelation matrix estimate are represented by the following equations:

$\hat{\mathbf{R}}_f = \mathbf{Q}_f \Lambda_f \mathbf{Q}_f^H$; and

$\hat{\mathbf{R}}_r = \mathbf{Q}_r \Lambda_r \mathbf{Q}_r^H$;

where the matrices $\mathbf{Q}$ are comprised of eigenvectors of corresponding matrices $\mathbf{R}$; and

matrices Λ are diagonal, containing eigenvalues of $\mathbf{R}$.

19. The method of improving transmit antenna weight tracking as defined in Claim 18, wherein the forward channel autocorrelation matrix estimate and the reverse channel autocorrelation matrix estimate are modified by exponentiation represented by the following equations:

$\hat{\mathbf{R}}_f{}^p = \mathbf{Q}_f \Lambda_f{}^p \mathbf{Q}_f^H$; and

$\hat{\mathbf{R}}_r{}^p = \mathbf{Q}_r \Lambda_r{}^p \mathbf{Q}_r^H$.

20. The method of improving transmit antenna weight tracking as defined in Claim 14, wherein the forward channel autocorrelation matrix estimate and the reverse channel autocorrelation matrix estimate jointly generate a modified matrix represented by the following equation:

$$\hat{\mathbf{R}}_{f,r}{}^p = \left(a_f \frac{\hat{\mathbf{R}}_f}{\left\| \hat{\mathbf{R}}_f \right\|} + a_r \frac{\hat{\mathbf{R}}_r}{\left\| \hat{\mathbf{R}}_r \right\|} \right)^p = \mathbf{Q}_{f,r} \Lambda_{f,r}{}^p \mathbf{Q}_{f,r}^H .$$

21. The method of improving transmit antenna weight tracking as defined in Claim 14, wherein the generating the perturbation vector autocorrelation matrix sub-act (3) generates the perturbation vector autocorrelation matrix by the following equation:

$$\mathrm{R}_{\mathrm{v}} = 2\left(a_f \frac{\hat{\mathrm{R}}_{\mathrm{f}}}{\left\|\hat{\mathrm{R}}_{\mathrm{f}}\right\|} + a_r \frac{\hat{\mathrm{R}}_{\mathrm{r}}}{\left\|\hat{\mathrm{R}}_{\mathrm{r}}\right\|} + \left(1 - a_r - a_f\right)\mathrm{I} \right)^{\mathrm{p}} .$$

22. The method of improving transmit antenna weight tracking as defined in Claim 21, wherein the method utilizes eigendecompositions to generate the perturbation vector autocorrelation matrix.

23. The method of improving transmit antenna weight tracking as defined in Claim 22, wherein the forward channel autocorrelation matrix estimate and the reverse channel autocorrelation matrix estimate are represented by the following equations:

$\hat{\mathbf{R}}_f = \mathbf{Q}_f \Lambda_f \mathbf{Q}_f^H$; and

$\hat{\mathbf{R}}_r = \mathbf{Q}_r \Lambda_r \mathbf{Q}_r^H$;

where the matrices **Q** are comprised of eigenvectors of corresponding matrices **R**; and

matrices Λ are diagonal, containing eigenvalues of **R**.

24. The method of improving transmit antenna weight tracking as defined in Claim 23, wherein the forward channel autocorrelation matrix estimate and the reverse channel autocorrelation matrix estimate are modified by exponentiation represented by the following equations:

$\hat{\mathbf{R}}_f{}^p = \mathbf{Q}_f \Lambda_f{}^p \mathbf{Q}_f^H$; and

$\hat{\mathbf{R}}_r{}^p = \mathbf{Q}_r \Lambda_r{}^p \mathbf{Q}_r^H$.

25. The method of improving transmit antenna weight tracking as defined in Claim 1, wherein the channel autocorrelation matrix estimate of a forward channel gain vector is based on a receiver position/environment data.

26. The method of improving transmit antenna weight tracking as defined in Claim 25, wherein the receiver position/environment data comprises angle of arrival.

27. The method of improving transmit antenna weight tracking as defined in Claim 25, wherein the receiver position/environment data comprises angular spread of a channel.

28. The method of improving transmit antenna weight tracking as defined in Claim 25, wherein the receiver position/environment data comprises geographical position of a mobile station.

29. The method of improving transmit antenna weight tracking as defined in Claim 28, wherein an angle of arrival is based on the geographical position of a mobile station.

30. The method of improving transmit antenna weight tracking as defined in Claim 28, wherein the geographical position of a mobile station is based on Global Positioning System (GPS) data.

31. An apparatus that improves transmit antenna weight tracking in a communication system, wherein the communication system includes a transmitter and a receiver, wherein the transmitter includes a plurality of antennae, and wherein the communication system is capable of communicating with a transmit adaptive antenna weighting technique, comprising:

a) means for determining a channel autocorrelation matrix estimate of a forward channel gain vector; and

b) means, responsive to the determining a channel autocorrelation matrix estimate of a forward channel gain vector means, for determining a transmitter antenna weight vector based on feedback from the receiver and the channel autocorrelation matrix estimate determined by the determining a channel autocorrelation matrix estimate of a forward channel gain vector means.

32. The apparatus as defined in Claim 31, wherein the determining a transmitter antenna weight vector means of Claim 31 comprises the following:

i) means for determining a perturbation vector autocorrelation matrix based on the determining a channel autocorrelation matrix estimate of a forward channel gain vector means;

ii) means, responsive to the determining a perturbation vector autocorrelation matrix means, for generating a perturbation vector having an autocorrelation given by the determining a perturbation vector autocorrelation matrix means;

iii) means, responsive to the generating a perturbation vector having an autocorrelation means, for utilizing the perturbation vector from the generating a perturbation vector having an autocorrelation means in a waveform transmitted from the transmitter; and

iv) means, responsive to the utilizing the perturbation vector means, for utilizing a measurement of the waveform transmitted from the transmitter at the receiver to generate feedback.

33. The apparatus as defined in Claim 31, wherein the determining a channel autocorrelation matrix estimate means comprises means for calculating a reverse channel autocorrelation matrix estimate.

34. The apparatus as defined in Claim 31, wherein the determining a perturbation vector autocorrelation matrix means comprises means for calculating the perturbation vector autocorrelation matrix from a forward channel autocorrelation matrix and a reverse channel autocorrelation matrix according to the following equation:

$$\mathbf{R}_v = 2\left(a_f \frac{\hat{\mathbf{R}}_f}{\left\|\hat{\mathbf{R}}_f\right\|} + a_r \frac{\hat{\mathbf{R}}_r}{\left\|\hat{\mathbf{R}}_r\right\|} + \left(1 - a_f - a_r\right)\mathbf{I} \right);$$

where a_f and a_r are algorithm parameters, wherein $0 \leq a_f \leq 1$, $0 \leq a_r < 1$, and $0 \leq (a_f + a_r) \leq 1$.

35. The apparatus as defined in Claim 34, wherein the determining a perturbation vector autocorrelation matrix means comprises:

(1) means for calculating a forward channel autocorrelation matrix estimate;

(2) means for calculating a reverse channel autocorrelation matrix estimate; and

(3) means, responsive to the forward channel autocorrelation matrix estimate means and the reverse channel autocorrelation matrix estimate means, for utilizing eigendecompositions to generate the perturbation vector autocorrelation based on estimates from the forward channel autocorrelation matrix estimate means and the reverse channel autocorrelation matrix estimate means.

36. The apparatus as defined in Claim 31, wherein the determining a perturbation vector autocorrelation matrix means comprises:

   i) means for calculating a forward channel perturbation vector autocorrelation matrix utilizing eigendecompositions; and

   ii) means for calculating a reverse channel perturbation vector autocorrelation matrix utilizing eigendecompositions.

37. A communication system, capable of improving transmit antenna weight tracking and communicating with a transmit adaptive antenna weighting technique, comprising:

a) a transmitter, capable of:

i) determining a channel autocorrelation matrix estimate of a forward channel gain vector;

ii) determining a perturbation vector autocorrelation matrix based on the channel autocorrelation matrix estimate;

iii) generating a perturbation vector having an autocorrelation associated with the perturbation vector autocorrelation matrix;

iv) determining a weight vector that is based on the perturbation vector and a TxAA algorithm that incorporates a feedback from a receiver; and

b) a receiver, capable of:

i) receiving a signal based on the perturbation vector; and

ii) generating feedback based on the signal.

38. The apparatus as defined in Claim 37, wherein the receiver is in soft handoff, and wherein a plurality of transmitters transmit to the receiver.

39. The apparatus as defined in Claim 38, wherein the plurality of transmitters transmit information regarding multiple antenna transmission to each other via a backhaul.

40. The apparatus as defined in Claim 39, wherein the plurality of transmitters transmit information regarding positioning to each other via a backhaul.

41. A transmitter, comprising:

a) a channel autocorrelation matrix estimator, capable of estimating a channel autocorrelation matrix of a forward channel gain vector;

b) a perturbation vector autocorrelation matrix calculator, responsive to the channel autocorrelation matrix estimator, capable of determining a perturbation vector autocorrelation matrix based on the channel autocorrelation matrix estimate;

c) a perturbation vector generator, responsive to the perturbation vector autocorrelation matrix calculator, capable of generating a perturbation vector having an autocorrelation associated with the perturbation vector autocorrelation matrix; and

d) a weight vector calculator, responsive to the perturbation vector generator, capable of determining a weight vector that is based on the perturbation vector and a TxAA algorithm that incorporates a feedback from the receiver.

42. The transmitter as defined in Claim 41, wherein the channel autocorrelation matrix estimator comprises a forward channel autocorrelation estimator, capable of calculating a forward channel autocorrelation matrix estimate.

43. The transmitter as defined in Claim 41, wherein the channel autocorrelation matrix estimator comprises a reverse channel autocorrelation estimator, capable of calculating a reverse channel autocorrelation matrix estimate.

44. The transmitter as defined in Claim 43, wherein the reverse channel autocorrelation matrix estimator comprises:

i) a coherent channel vector estimator, capable of calculating a coherent channel vector estimate $\hat{\mathbf{c}}$ by multiplying a receiver waveform with a local version of a reverse channel pilot sequence conjugated and filtering the resultant with a filter;

ii) an outer product calculator, responsive to the coherent channel vector estimator, capable of calculating an outer product $\hat{\mathbf{c}}\hat{\mathbf{c}}^H$; and

iii) a filter, responsive to the outer product calculator, capable of filtering the outer product $\hat{\mathbf{c}}\hat{\mathbf{c}}^H$ to produce the reverse channel autocorrelation matrix estimate.

45. The transmitter as defined in Claim 41, wherein the channel autocorrelation matrix estimator comprises:

i) a forward channel autocorrelation matrix estimator, capable of calculating a forward channel autocorrelation matrix estimate utilizing eigendecompositions; and

ii) a reverse channel autocorrelation matrix estimator, capable of calculating a reverse channel autocorrelation matrix estimate utilizing eigendecompositions.